PATENT APPLICATION

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re application of

Yasuki KIMURA

Docket No: Q87054

Appln. No.: 10/529,152

Group Art Unit: 1792

Confirmation No.: 1832

Examiner: Allan W. Olsen

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For: METHOD OF ETCHING CHROMIUM THIN FILM AND METHOD OF PRODUCING PHOTOMASK

DECLARATION UNDER 37 C.F.R. § 1.132

Mail Stop Amendment
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Sir:

I, Yasuki KIMURA, hereby declare and state:

THAT I am a citizen of Japan;

THAT I have received the Master degree of nuclear physics in 1983 from Tohoku University;

THAT I have been employed by HOYA Corporation since 2000, where I hold a position as Senior Development Engineer, with responsibility for research on photomask fabrication, microlithography and Dry etching;

1) I, Yasuki Kimura, have been involved in research and development of photomasks for use in manufacture of LSIs since 1983.

From 2000, I have been engaged in the above-mentioned research and development in HOYA CORPORATION, the assignee of the present application. I am affiliated with JSAP (Japan Society of Applied Physics) and SPIE (International Society for Optical Engineering) also.

2) I understand the present invention and the cited reference, Kwon et al, in Loading Effect Parameters at Dry Etcher System and Their Analysis at Mask-to-Mask Loading and Within-Mask Loding, SPIE Vol. 4562 pp. 79-87 (hereafter, Kwon), and hereby present this Declaration in order to show that the cited reference does not disclose the present invention and that the present invention can not easily be conceived from the cited reference by those skilled in the art.

3) The cited reference, Kwon, discloses the loading effect when the Cr film is etched by the use of a mixed gas of oxygen and chlorine and describes the relationship between the loading effect and various parameters. Referring to Fig. 2(a), the etching rates of the positive resist and Cr are monitored when the source power is varied from 140 to 250W. With such disclosure, however, Kwon does neither disclose nor suggest "to use a power lower than a specific power at which plasma density jump occurs" in the present invention. The reason will be given below.

4) The value of the source power at which plasma density jump occurs is variable dependent on various factors. For example:

- source power actually supplied to plasma (each apparatus such as an etching apparatus inevitably has a power loss in a circuit; such the power loss is not the same for each individual apparatus; therefore, a setup power is not always equal to a power actually supplied to plasma)
- plasma generating volume (mainly dependent on the volume and the shape of the chamber)
- gas pressure inside the chamber
- internal structure of the chamber (positional relationship between the substrate, gas supplying portion and electrodes)
- gas composition ratio, total flow rate, etc.

Therefore, even if a specific source power is applied, plasma apparatuses with different structure will have different plasma generating performance. Thus, it is impossible to determine

whether the specific source power above the power plasma density jump occurs for one apparatus is necessarily above that power for another apparatus. Such source power which causes the plasma density jump for a particular apparatus can be obtained only after confirming the phenomenon of plasma density jump in the apparatus and finding the source power upon occurrence of the phenomenon.

5) I was dedicated to studying how to obtain excellent etching characteristics (minimizing etching conversion difference between the resist and the Cr film, CD linearity, and the sectional shape of the opening of the Cr film) when the Cr film is etched by the use of the ICP etching apparatus used in making the present invention. As a result, I have found out that the etching characteristics has strong relation with a plasma exciting power corresponding to density jump, i.e., drastic increase of the electron density of plasma in the etching apparatus. Herein, a specific power which causes plasma density jump is determined by actually monitoring occurrence of the density jump in the plasma chamber while the power is gradually changed. It has been found out that, when a power lower than the specific power is applied, excellent etching characteristics are obtained. For example, as shown in Fig.. 6 of the present application, a Cr film pattern substantially having no error with respect to the designed dimension was obtained.

6) Plasma density jump was monitored in the following manner. Using a particular etching apparatus (for example, having the structure schematically shown in Fig. 2 of the present application), the ICP power is supplied while the gas described in Example 1 is supplied. When the power is gradually increased, plasma density jump occurs at a particular time instant. Then, drastic change is observed in an emission spectrum in the chamber. Specifically, the amount of light detected by a spectrometer is drastically and discontinuously increased (which may be visually observed also). Alternatively, drastic reduction of the value of Vdc (dc component of RF bias) or Vpp (peak-to-peak amplitude of RF bias) may be monitored.

7) When the specific apparatus is used, the above-mentioned experiment is repeatable and reproducible. In the present specification, I described the conditions actually used upon making the present invention. On the other hand, generally, the etching behavior is significantly affected and varied due to differences in each apparatus structure or its operating conditions. It is extremely difficult to produce the identical condition of plasma with the different apparatus, this is known to those skilled in the art. Various factors mentioned in the above section 4) affect the behavior of the plasma generated in the etching chamber. Accordingly, even if the ICP

power is set at the same power level, plasma density jump will not always occur at the same power level as long as the apparatuses and/or their conditions are different from one another. On the other hand, a person who is going to put the present invention into practice can confirm a specific power at which plasma density jump occurs in the etching apparatus used by him. Once it is done, then, by using the power level lower than the specific power, the advantages of the present invention can be obtained. In other words, as long as the power at which plasma density jump occurs is not confirmed, it is impossible to know whether an operating power used in each apparatus is higher or lower than the specific power corresponding to plasma density jump.

8) It is noted that, according to Fig. 2(a) of Kwon, the etching rate of Cr is linearly increased with an increase in source power. If plasma density jump occurs, the linearity of the etching rate of Cr has to be affected. Therefore, in view of this figure, even the presence of plasma density jump can not be recognized.. Also, it is impossible from the figure to judge whether plasma density jump occurs at a power not higher than 140 W or at a power not lower than 250 W.

9) Prior to the present invention, it is not easily conceived to select lower power within a particular range when the etching conditions upon deposition are determined. This is because it is well known to those skilled in the art that the etching efficiency is lowered when the power is lowered.

10) It is essential to determine, in the etching apparatus to be used and under the etching conditions to be used, the power level at which plasma density jump occurs (typically, by means of preliminary experiment) and to apply to actual etching a power level lower than the determined power level at which plasma density jump occurs. This can be done only after (1) the phenomenon of plasma density jump is observed, (2) the specific power at which the phenomenon occurs is found, and (3) a power lower than the specific power is applied and the advantages obtained thereby is recognized.

11) According to the present invention, I could obtain excellent etching characteristics by using a power lower than the power level at which plasma density jump occurs. This is an effect truly beyond expectation.

12) On the other hand, the cited reference Kwon does not include any disclosure suggesting the present invention even if the whole disclosure is read through. Furthermore, it is impossible to know whether or not the depositing conditions used in Kwon satisfy the present claims.

I declare further that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Date: 05/June/2008

Yasuki Kimura

Yasuki KIMURA